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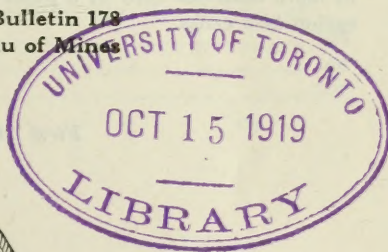
BUREAU OF MINES

VAN. H. MANNING, DIRECTOR

EXPLOSIVES AND MISCELLANEOUS  
INVESTIGATIONS

EXPLOSIVES RESEARCH, REGULATION OF EXPLOSIVES  
AND PLATINUM, MARINE-BOILER TESTS, UNDERGROUND  
SOUND RANGING, TRAINING IN FIRST AID AND RESCUE  
WORK, CENSUS OF MINING ENGINEERS AND CHEMISTS,  
PREPARATION OF ALLOY STEELS, LIGHTING  
AVIATION FIELDS, COOPERATION WITH  
CAPITAL ISSUES COMMITTEE

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DEPARTMENT OF THE INTERIOR  
BUREAU OF MINES  
EXPLOSIVES AND MISCELLANEOUS INVESTIGATIONS

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## CONTENTS.

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|                                                                               | Page. |
|-------------------------------------------------------------------------------|-------|
| Explosives research.....                                                      | 89    |
| Cooperative work for Army and Navy Departments.....                           | 89    |
| Investigations of explosions.....                                             | 90    |
| Explosives regulation.....                                                    | 92    |
| Regulation of platinum and allied metals.....                                 | 95    |
| Tests of marine boilers for the United States Shipping Board.....             | 96    |
| Sound detection and sound ranging.....                                        | 99    |
| Training in first-aid and rescue work.....                                    | 102   |
| Census of mining engineers, metallurgists, and chemists.....                  | 103   |
| Investigations of alloy steels.....                                           | 105   |
| Cooperative work with the Ordnance Department.....                            | 105   |
| Cooperative work with the Navy Department and the Bureau of<br>Standards..... | 105   |
| Lighting device for aviation fields.....                                      | 106   |
| Cooperation with Capital Issues Committee.....                                | 107   |





## EXPLOSIVES AND MISCELLANEOUS INVESTIGATIONS.

### EXPLOSIVES RESEARCH.

As the physical laboratories of the explosives section of the Pittsburgh experiment station were equipped for testing the physical properties of explosives, both the Army and Navy Departments for many years had requested the Bureau of Mines to make such tests.

Chemical control of the physical tests through analyses, heat tests, analyses of gaseous products of combustion, and sand tests was exercised through the explosives chemical laboratory.

Often an investigation was cooperative between two laboratories. The explosives chemical laboratory also aided the work of the Explosives Regulation both by chemical tests and investigation of accidents in explosives plants.

### COOPERATIVE WORK FOR ARMY AND NAVY DEPARTMENTS.

The explosives chemical laboratory devised, at the request of the Bureau of Ordnance of the Navy, a more economical method of making hexanitrodiphenylamine. This problem was assigned to the Bureau of Mines by Dr. C. E. Munroe, chairman of the committee on explosives of the National Research Council, acting as the department of science and research of the Council of National Defense.

Before the United States entered the war the following reports of investigations were submitted to the Army or the Navy:

1. Report of sensitiveness and relative efficiency of TNT and ammonium picrate, dated February 6, 1913, undertaken at the request of the Chief of Ordnance.

2. Report of tests and examination of two samples of TNT and one of TNA for the Ordnance Department of the Army, dated August 5, 1915, was undertaken at the request of commanding officer, Frankford Arsenal.

3. Report of tests for sensitiveness to detonation of mercury fulminate of 21 samples of TNT crystallized from various solvents, for the Bureau of Ordnance, Navy Department, dated June 17, 1916.

4. Report of tests of two samples of mercury fulminate for Frankford Arsenal, dated December 2, 1916, undertaken at the request of the commanding officer, Frankford Arsenal.

After the United States entered the war the following reports of investigations were submitted:

5. Report of pendulum friction and large impact tests on two samples of "sodatol" and two samples of "amatol." The final report was dated July 20, 1918; and the preliminary report, May 15, 1918. This investigation was undertaken at the request of the Ordnance



Department, War Department, to determine the sensitiveness to shock and friction of sodatol and amatol at high temperatures.

6. Fifteen reports of tests of explosives for the United States Engineers, to determine the relative strength and efficiency of eight samples of explosives for use in military mining and demolition operations.

The data obtained from these tests will be used for preparing a manual on demolition work and explosives for officers and noncommissioned officers of the United States Engineers, on which the captain assigned to aid in the tests is now working.

7. Seventeen reports of tests on explosives for the Ordnance Department.

This investigation was undertaken at the request of Engineering Explosives, Ordnance Department of the Army, to determine the physical characteristics, relative efficiency, and strength under varying conditions of 13 explosives used as bursting charges and boosters. In addition, special minor investigations were carried out.

The results of the completed work will be used as the "Standard physical properties of these explosives" by the War Department.

8. Miscellaneous tests. The Bureau of Mines physical testing laboratory was called upon to make special tests for the American University experiment station. These included products-of-combustion tests of "tetryl" and Bichel pressure gage tests of "carolnite."

9. Almost immediately after this country entered the war, the explosives section of the Bureau of Mines was requested by both the Army and Navy Departments to furnish all information available and reports of tests on numerous explosives. In addition, drawings and advice on the construction of testing apparatus was furnished to different stations of the Army and Navy.

#### INVESTIGATIONS OF EXPLOSIONS.

In connection with the work of explosives regulation members of the explosives section and the explosives chemical laboratory inspected explosives plants and investigated accidents in explosives plants and attended conferences.

The accidents investigated and reported upon were as follows:

##### *Accidents at explosive plants.*

| Plant.                            | Location.            | Date of accident. |
|-----------------------------------|----------------------|-------------------|
|                                   |                      | 1917.             |
| Grasselli Powder Co.....          | New Castle, Pa.....  | June 12           |
| G. R. McAbee Powder & Oil Co..... | Tunnelton, Pa.....   | Nov. 7            |
| American Zinc Co.....             | Mascot, Tenn.....    | Nov. 22           |
| Aetna Chemical Co.....            | Heidelberg, Pa.....  | Dec. 5            |
| Aetna Explosives Co.....          | Carnegie, Pa.....    | Do.               |
| Bethlehem Steel Co.....           | New Castle, Del..... | Dec. 12           |
| Newark Rubber Co.....             | Newark, N. J.....    | Dec. 22           |

*Accidents at explosive plants—Continued.*

| Plant.                                       | Location.                         | Date of accident. |
|----------------------------------------------|-----------------------------------|-------------------|
|                                              |                                   | 1918.             |
| Atlas Powder Corporation.....                | Patterson, Okla.....              | Jan. 10           |
| Hercules Powder Co.....                      | Kenvil, N. J.....                 | Jan. 22           |
| Do.....                                      | Valley Falls, N. Y.....           | Jan. 31           |
| E. I. du Pont de Nemours & Co.....           | Butte, Mont.....                  | Do.               |
| Do.....                                      | Welpen, Minn.....                 | Feb. 20           |
| Do.....                                      | Repauno, N. J.....                | Feb. 21           |
| Do.....                                      | Wayner N. J.....                  | Feb. 25           |
| Do.....                                      | Hopewell, Va.....                 | Mar. 2            |
| Hercules Powder Co.....                      | Gillespie, N. J.....              | Mar. 18           |
| Trojan Powder Co.....                        | Iron Bridge, Pa.....              | Mar. 26           |
| Jarvis Warehouse.....                        | Jersey City, N. J.....            | Do.               |
| International Explosives Co.....             | Swanton, Vt.....                  | Mar. 28           |
| Atlas Powder Co.....                         | Scottdale, Pa.....                | Mar. 29           |
| Aetna Explosives Co.....                     | Poacher Plant.....                | Do.               |
| Hercules Powder Co.....                      | Gillespie, N. J.....              | Apr. 5            |
| National Chemical Mfg. Co.....               | Hunkers, Pa.....                  | Apr. 16           |
| E. I. du Pont de Nemours & Co.....           | Carneys Point, N. J.....          | Apr. 19           |
| Hercules Powder Co.....                      | Carthage, Mo.....                 | Apr. 22           |
| Do.....                                      | Hercules, Calif.....              | Apr. 25           |
| E. I. du Pont de Nemours & Co.....           | Deepwater, N. J.....              | Apr. 26           |
| Hercules Powder Co.....                      | Bacchus, Utah.....                | May 6             |
| Do.....                                      | Kenvil, N. J.....                 | May 8             |
| Do.....                                      | Youngstown, Ohio.....             | May 9             |
| Do.....                                      | Marlow, Tenn.....                 | May 11            |
| E. I. du Pont de Nemours & Co.....           | Jermyn, Pa.....                   | May 17            |
| Aetna Chemical Co.....                       | Oakdale, Pa.....                  | May 18            |
| Aetna Explosives Co.....                     | Emporium, Pa.....                 | May 31            |
| Hercules Powder Co.....                      | Kenvil, N. J.....                 | June 2            |
| Do.....                                      | do.....                           | June 10           |
| Aetna Explosives Co.....                     | Ishpeming, Mich.....              | June 12           |
| Hercules Powder Co.....                      | Ferndale, Pa.....                 | June 14           |
| Do.....                                      | Gillespie, N. J.....              | June 19           |
| Grasselli Powder Co.....                     | New Castle, Pa.....               | June 25           |
| Aetna Explosives Co.....                     | Mount Union, Pa.....              | July 2            |
| Semet Solvay Co.....                         | Syracuse, N. Y.....               | Do.               |
| Hercules Powder Co.....                      | Kenvil, N. J.....                 | Do.               |
| Newtons California Manufacturing Co.....     | San Francisco, Calif.....         | July 3            |
| Hercules Powder Co.....                      | Kenvil, N. J.....                 | July 5            |
| E. I. du Pont de Nemours & Co.....           | Carneys Point, N. J.....          | July 10           |
| Aetna Explosives Co.....                     | Ishpeming, Mich.....              | July 19           |
| Do.....                                      | Goes, Ohio.....                   | July 20           |
| Bethlehem Steel Co.....                      | Redington, Pa.....                | Do.               |
| Standard Powder Co.....                      | Pittsburgh, Pa.....               | July 23           |
| Atlas Powder Co.....                         | Reynolds, Pa.....                 | July 28           |
| Aetna Explosives Co.....                     | Aetna, Ind.....                   | July 30           |
| E. I. du Pont de Nemours & Co.....           | Carneys Point, N. J.....          | Aug. 1            |
| Do.....                                      | Barksdale, Wis.....               | Aug. 2            |
| Grasselli Powder Co.....                     | New Castle, Pa.....               | Aug. 5            |
| Hercules Powder Co.....                      | Kenvil, N. J.....                 | Aug. 7            |
| Illinois Powder Manufacturing Co.....        | Easton, Ill.....                  | Aug. 8            |
| American Standard Metal Products Co.....     | Paulsburry, N. J.....             | Do.               |
| G. R. McAbee Powder & Oil Co.....            | Tunnelton, Pa.....                | Aug. 10           |
| Hercules Powder Co.....                      | Kenvil, N. J.....                 | Aug. 14           |
| Trojan Powder Co.....                        | Seiple, Pa.....                   | Do.               |
| Stauffer Chemical Co.....                    | Chauncey, N. Y.....               | Aug. 19           |
| Standard Powder Co.....                      | Pittsburgh, Pa.....               | Aug. 10           |
| Eddystone Munitions Co.....                  | Eddystone, Pa.....                | Sept. 11          |
| E. I. du Pont de Nemours & Co.....           | Barksdale, Wis.....               | Sept. 15          |
| Aetna Chemical Co.....                       | Carnegie, Pa.....                 | Sept. 17          |
| E. I. du Pont de Nemours & Co.....           | Wilmington, Del.....              | Sept. 22          |
| Trojan Powder Co.....                        | Allentown, Pa.....                | Oct. 2            |
| Aetna Chemical Co.....                       | Carnegie, Pa.....                 | Oct. 9            |
| E. I. du Pont de Nemours & Co.....           | Wilpen, Minn.....                 | Oct. 12           |
| T. A. Gillespie Loading Co.....              | Morgan, N. J.....                 | Oct. 14           |
| Western Powder Manufacturing Co.....         | Edwards, Ill.....                 | Nov. 12           |
| Grasselli Powder Co.....                     | Quaker Falls, Pa.....             | Nov. 25           |
| E. I. du Pont de Nemours & Co.....           | Oliver Mills, Pa.....             | Dec. 7            |
| Do.....                                      | Moosie, Pa.....                   | Dec. 19           |
|                                              |                                   | 1919.             |
| Hercules Powder Co.....                      | Hercules, Calif.....              | Jan. 7            |
| E. I. du Pont de Nemours & Co.....           | Deepwater Point, N. J.....        | Jan. 10           |
| Grasselli Powder Co.....                     | New Castle, Pa.....               | Feb. 3            |
| Egyptian Powder Co.....                      | Pollard, Ill.....                 | Feb. 10           |
| General Explosives Co.....                   | Joplin, Mo.....                   | Feb. 19           |
| Winchester Repeating Arms Co.....            | New Haven, Conn.....              | Mar. 1            |
| Western Powder Co.....                       | Edwards, Ill.....                 | Mar. 2            |
| Grasselli Powder Co.....                     | Wayside, Pa.....                  | Mar. 5            |
| E. I. du Pont de Nemours & Co.....           | Gibbstown, N. J.....              | Mar. 11           |
| Aetna Explosives Co.....                     | North Birmingham, Ala.....        | Do.               |
| Ordnance Department, United States Army..... | Aberdeen Proving Grounds, Md..... | Mar. 28           |



The following plants were inspected: Grasselli Powder Co., New Castle, Pa.; Aetna Explosives Co., Mount Union, Pa.

The explosives section was also requested by the Department of Justice to investigate explosions, give advice on destruction of confiscated explosives, and examine incendiary and explosive bombs.

### EXPLOSIVES REGULATION.

The preamble to the explosives-regulation act, approved October, 1917 (40 Stat., 385), sets forth briefly the purpose of the act as follows:

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That when the United States is at war it shall be unlawful to manufacture, distribute, store, use, or possess powder, explosives, blasting supplies, or ingredients thereof, in such manner as to be detrimental to the public safety, except as in this act provided.*

This act was passed after seven months of preparatory work, during which time officials of the large powder companies, officers of the Ordnance Department of the United States Army, and various experts on explosives and on legal matters were consulted. The administration of the act was delegated to the Director of the Bureau of Mines, as this bureau, through its work on mine explosives, was best equipped for the purpose.

One of the primary objects of the act was to prevent explosives from getting into the hands of persons hostile to the United States Government. An essential provision was the requirement of licenses, no person being permitted to manufacture or possess explosives or their ingredients without holding a license, in order to protect these articles from theft and also from loss or destruction.

It was evident that the enforcement of such a law throughout the United States, Alaska, and insular possessions would entail an extensive and thorough organization, as under the law not only were all common explosives included, but also ingredients that are household necessities, and would involve the issuing, after investigation, of more than 1,000,000 licenses. To this end an organization was established as follows:

The Director of the Bureau of Mines, under section 18 of the act, was authorized to make rules and regulations for carrying its provisions into effect, subject to the approval of the Secretary of the Interior. A new division of the bureau, known as the Explosives Regulation, was organized by the director, and F. S. Peabody was placed in charge, as assistant to the director in charge of explosives. The chief branches of this office were: (1) Administrative and questions of policy; (2) investigation of applications and the issuing of manufacturer's, exporter's, and importer's licenses, which have numbered



approximately 918; (3) examination and appointment of field employees; (4) investigation and prosecution of violations of the act; (5) proper storage of explosives or ingredients.

In each State and in the Territory of Alaska, an explosive inspector was appointed by the President, with the approval of the Senate. Each field inspector acted under the supervision of the Washington office.

Under each explosives inspector was an advisory committee, which was made up, when practicable, of representatives of those interests most affected, such as the Council of National Defense, the Department of Justice, Department of Agriculture, a fire insurance company, a casualty company, a large dealer in and user of explosives, or a manufacturer of explosives. The members of the advisory committee were designated assistant inspectors, and rendered the explosive inspector such assistance as lay within their power. They were appointed by the Director of the Bureau of Mines, with the approval of the Secretary of the Interior.

The Bureau of Explosives, New York City, acted in close cooperation with the explosives division of the Bureau of Mines; it handled all cases relative to explosives or ingredients while in transit in public carriers, and its inspectors throughout the country assisted the Federal explosives inspector in every way possible.

For licensing users of explosives and ingredients a field force of over 15,000 men was selected and appointed by the Director of the Bureau of Mines after investigation was made as to loyalty and as to their having unlimited power to administer oath and their not being connected or interested in any way with the manufacture or sale of explosives or ingredients.

Less than 1 per cent of the entire force under the explosives act received salaries for this work, and the work was so systematized that the active force required in the Washington office numbered not more than 50 persons.

In the enforcement of the act it was found that in many mining districts the miners not only had free access to explosives, but made a common practice of carrying explosives home. It was not uncommon to find 500 to 800 pounds of explosives in a single miners' lodging house, and statistics show that many accidents have happened from miners filling their paper cartridges by the light of ordinary oil lamps. The Explosives Regulation made vigorous efforts to stop this practice. In Kansas and Alabama, for instance, about 80 per cent of the practice was largely abolished through the cooperation of the mine operators in issuing or selling the explosives to the men at the mine, thereby reducing the necessity of carrying the explosives to lodging houses.

In examining magazines it was found that in thousands of instances explosives were stored so carelessly that theft would have been easy, or were stored in such close proximity to dwellings, highways, or railroads as to constitute a serious menace. Quantities up to 10,000 pounds in a single magazine were found in the heart of a town, where an explosion would have resulted in great loss of life and property. Several attempts to dynamite railroad bridges and other structures, with the object of hampering the transportation or equipment of troops, were reported to the bureau by the War Department. Also on several occasions the War Department appealed to the Bureau of Mines to remove the menace caused by the proximity to mobilization camps of improperly constructed, unguarded magazines. Among these may be mentioned three powder storehouses at Possession Point, State of Washington, considered to be insufficiently and improperly guarded; magazines of two powder companies situated in the vicinity of St. Paul, Minn.; magazines owned by three powder companies in the vicinity of Camp Zachary Taylor, Ky.

The number of magazines listed exceeds 8,000, particulars of additional ones being received daily in owner's reports, in the form of an affidavit, showing detailed construction, situation, and contents. These are checked up and recommendations are made whereby the magazines will not only be reasonably proof against theft but also safely situated with respect to life, limb, and property.

Acting upon instructions, special investigations were made in the field by the inspectors or their assistants of refusals or revocations of licenses, improper storage facilities, violations of the act, and outrages against life and property by the use of bombs and other explosives. There have been over 15,000 special investigations made and over 100 convictions obtained for violation of the act.

The personnel of the division has always received the active cooperation of the officials of the Army, Navy, and other Federal departments, and of State authorities. In making investigations the Explosives Regulation is authorized by law to request the assistance of Federal or State authorities.

The policy in general as regards technical offenses was to seek fines rather than terms of imprisonment; however, when the offense seemed grave enough, prosecution was vigorously instigated. Sentences pronounced have ranged all the way up to \$5,000 and 11 months' imprisonment, the maximum sentence possible being one year's imprisonment and \$5,000 fine.

In a recent case in Detroit the defendant said that he could not buy powder, so had purchased cartridges at different stores, had cut them open and used the powder contained therein for making a bomb. The



jury rendered a verdict of guilty and the judge gave an option of \$500 fine and three months' imprisonment or one year's imprisonment without the fine. The inability to obtain powder, except through purchasing cartridges, was a result of the explosives act.

Through the field force, numerous cases of disloyalty have been reported which, as they do not come under the jurisdiction of the Department of the Interior, were turned over to the Department of Justice, with the result that many enemies were sentenced either to prison or to the internment camps. As further evidence of the benefits which accrued under the act, it should be mentioned that various States are now planning effective legislation to replace the act when it becomes inoperative.

The personnel of the explosives division has remained practically the same, except that F. S. Peabody, acting as assistant to the director in charge of explosives, resigned on July 17, 1918, and was succeeded by Clarence Hall on July 18, 1918, with the title of chief explosives engineer.

On November 14, 1918, some of the commodities listed as requiring license were exempted as no longer coming under the law except under certain special circumstances. This modification was made because of the signing of the armistice and applied to ingredients of explosives and fireworks.

### REGULATION OF PLATINUM AND ALLIED METALS.

Platinum being essential to the production of explosives, it became imperative, when the United States entered the war, to ascertain the demand for and the supply of the metal in this country. In the early part of 1917, the chemical division of the War Industries Board, through an order from the Secretary of the Treasury, took the first steps toward conserving the supply, withholding all platinum that passed into the United States Mint. It was found that the different departments of the Government were unable to furnish exact estimates of their requirements, and as the demand for the metal grew, such estimates as were submitted had to be constantly increased. As an example, orders for 20,000 ounces were placed in June, 1917, in Russia, but by the time the metal was delivered in San Francisco the Government's requirements exceeded that amount.

By requisitioning the supplies in the hands of 14 of the leading firms in this country a certain amount was obtained, but owing to the inadequacy of the supply it became necessary to turn to the jewelers and appeal to the people at large throughout the country. Colombia was able to supply only about 2,500 ounces a month, and the collapse of the Russian Government aggravated the situation. A

loan of 10,000 ounces from England helped somewhat. By this time the estimated requirements for 1918 amounted to 36,400 ounces, but, as previously stated, these estimates kept increasing as the country took a larger part in the prosecution of the war. Because of the larger demand, Government regulation of the use and sale of platinum became imperative. Immediately the question arose as to which industries should be curtailed in their use of the metal, and it was decided that nonessential or "luxurious" uses could be eliminated, and that for various purposes, as far as possible, substitutes should be used to release platinum.

Both the War Department and the War Industries Board appreciated the necessity of licensing the users of platinum so that proper control over the metal could be obtained. It was decided, after due consideration, that the explosives regulation division of the Bureau of Mines would be the best organization to handle the matter, because of the licensing system it had established and the distribution of its 15,000 agents, working under a law that was controlling other commodities as a war measure. Accordingly, Congress, by the act of October 6, 1917 (40 Stat., 385), amended by the act of July 1, 1918 (Public, 181), authorized the Director of the Bureau of Mines, under rules and regulations approved by the Secretary of the Interior, to limit, during the period of the war, the sale, possession, and use of platinum, palladium, and iridium and compounds thereof.

On account of the signing of the armistice the restrictions this act placed on the manufacture, possession, purchase, sale, and use of platinum, palladium, iridium, and compounds were removed by the Director of the Bureau of Mines, with the approval of the Secretary of the Interior, on November 14, 1918.

#### **TESTS OF MARINE BOILERS FOR THE UNITED STATES SHIPPING BOARD.**

In February, 1918, F. W. Dean, of the Emergency Fleet Corporation, arranged with O. P. Hood, chief mechanical engineer, that the Bureau of Mines take temperature measurements at some tests of water-tube boilers being designed and built for the emergency fleet. Henry Kreisinger, fuel engineer of the bureau, arranged details and conducted the tests.

In April, 1918, one of the boilers was ready for test at the Erie City Iron Works, Erie, Pa. Mr. Kreisinger went to Erie about April 10, met Mr. Conti and Mr. Dean, of the Emergency Fleet Corporation, and discussed with them the plans of the work. It was agreed that the work the bureau should undertake was to make all temperature measurements and analyze the furnace gases. The Emergency Fleet Corporation did not have a skilled fireman, so that



an experienced fireman from the Pittsburgh experiment station of the bureau was used.

The first test was on April 18, and in all 22 tests were made at Erie with George's Creek coal. During each test temperatures were measured at several places inside the boiler setting, a total of several hundred readings being taken. These temperature measurements indicated that the performance of the boiler could be improved by changes in the baffling. These changes were made and the efficiency of the boiler was considerably increased.

During the first test the flue gases contained a considerable percentage of combustible matter. It was agreed that the bureau should study in more detail the process of combustion in the furnace. In this study a large number of samples of the furnace gases were taken and the analyses of these samples were carefully investigated. The investigation showed that it was difficult, if not impossible, to get air enough over the fuel bed to insure complete combustion. Hence a larger number of holes were made in the firing doors and in the furnace front to admit secondary air. These openings improved the combustion, but the furnace was small and not enough air could be admitted in this way, nor could the air be mixed thoroughly with the combustible gases rising from the fuel bed. Therefore it was decided to admit additional air at the rear of the furnace by using a Wager bridgewall, which is made of iron bars, somewhat like a grate, and admits air through the openings between the bars. Thus the combustible gases rising from the fuel bed were between two streams of air, one coming from the front of the furnace and one through the bridgewall. In consequence better mixing and improved combustion was obtained.

In the early tests the flue gases often contained so much combustible matter that they ignited and burned with a flame at the base of the stack. After admitting air through the bridgewall and the front of the furnace all flaming at the base of the stack ceased, showing that combustion within the furnace was more nearly complete. By these improvements in the furnace and the changes in the baffling, the over-all boiler efficiency was raised from about 60 per cent to 72 per cent. This high efficiency of 72 per cent was obtained when the boiler evaporated  $5\frac{1}{2}$  to 6 pounds of water per square foot of heating surface, a rate considerably higher than is the practice in the average stationary plant. Thus the fuel section of the Bureau of Mines helped to develop a highly efficient boiler. The tests of this furnace substantiated the results obtained by the bureau in laboratory investigations, namely, that enough air can not be supplied through the fuel bed to obtain complete combustion, and additional air must be introduced over the fuel bed.

The bureau developed a method for studying the flow of gases through the boiler by measuring the temperatures across the path of gases. It is believed work of this character had never before been undertaken. The engineers of the Emergency Fleet Corporation appreciated the value of the work done by the fuel section and gave the bureau due credit.

In August another boiler, at the Murray Iron Works, Burlington, Iowa, was ready for test. This boiler, designed by John F. Bell, of New York, for the Power Specialty Co., differed somewhat from the boiler tested at Erie, Pa., being fitted with a Foster superheater. The Emergency Fleet Corporation had ordered a large number of these boilers for steel ships and was interested in their performance as compared with that of the Erie boilers. It desired that the boiler be tested first with oil, using Dahl and Coen burners, and that then a hand-fired furnace be substituted and further tests made with Georges Creek coal as fuel. Consequently, the Emergency Fleet Corporation asked the bureau to do in these boiler tests work similar to that done at Erie, Pa., and, particularly, to furnish the same skilled firemen to do the firing in the test with coal.

In all, 32 tests were made with oil and 12 tests were made with coal. Members of the fuel section of the bureau made three trips to Iowa. There were three men on the first trip. On the second trip the Emergency Fleet Corporation asked that Mr. Kreisinger take charge of the whole test during the daytime and one of its men take charge at night. This necessitated the bureau supplying an extra man. On the third trip, during which the coal tests were made, the bureau was asked to furnish a fireman, so that it supplied five men on this trip. The coal tests were supervised by Mr. Kreisinger as the representative of the Emergency Fleet Corporation's interest in the tests.

The chief result of the work done by the bureau in these tests was the demonstration that a larger combustion space for burning oil gave better combustion and higher efficiency. In the test with coal the results showed that introducing secondary air through the firing doors, the furnace front, and a Wager bridge wall improved the combustion and increased the efficiency of the boiler. As the coal was fired by the same firemen and the tests were supervised by the same engineer, the results are directly comparable with those obtained at Erie.

As the expense connected with making the tests at Burlington was far in excess of the allotment of bureau funds available for that purpose, the Emergency Fleet Corporation was asked to bear part of the expense of the work. This the corporation agreed to do, and the agreement was used as a basis for further cooperation. The corporation intends to use the methods of the Bureau of Mines in testing all designs of boilers for its ships, the same crew and firemen to conduct the tests.



Subsequently the bureau tested another boiler at Erie, Pa., and in January, 1919, was planning to test two more—a large Scotch marine boiler at the Sun Shipbuilding Co. yards at Chester, Pa., and a boiler at the works of the Heine Boiler Co. at Phoenixville, Pa. All three boilers were to be tested with hand-fired furnaces and also with oil, using Dahl and Coen burners. In addition, the boiler at Erie, Pa., will be tested with a spreading stoker and with a type E underfeed stoker furnished by the Combustion Engineering Co.

Devices to supply additional air over the fuel bed at high velocity, so as to improve the mixing and thus the combustion in the furnace and increase the efficiency of the boiler, will also be tested. The devices will be tested with the object of using, in the new ships, those that prove practical and economical.

The United States Shipping Board is setting a new standard in marine boiler-plant engineering. It is developing highly efficient boilers and supplying trained men to operate the power plants of the ships.

By cooperating in the work on boilers the Bureau of Mines is enabled to apply on a practical scale some of the principles developed in its fuel laboratory at Pittsburgh, and to determine how far the deductions drawn from laboratory experiments are applicable to boilers of marine type. The data collected during the tests will be of value to all persons interested in the design of boiler furnaces and boilers, as work of this kind is believed to be new.

### SOUND DETECTION AND SOUND RANGING.

An investigation of decided military importance was that of sound detection and sound-ranging underground. By means of delicate listening devices—geophones and microphones—it is possible to tell by the sound waves transmitted through earth and rock the distance and the direction of points at which underground sapping or mining operations are being conducted. The attention of the mining division of the Bureau of Mines was called to the problem in 1917, through drawing specifications for self-contained breathing apparatus for use in underground work and in subsequently getting the Edison Co. to build Gibbs breathing apparatus for the Army. Capt. H. D. Trounce, of the Army, who had two years experience with the Royal Engineers before he was transferred to the American forces, was interested in the matter of detecting the sounds made by mining machines and through him the Bureau of Mines ascertained that Maj. W. D. Young, of the Engineers, had been assigned a problem relating to sound detection. Accordingly, the Director of the Bureau of Mines took up the offering of assistance to Maj. Gen. Black, Chief of Engineers, in the matter of sound detection and the use of the experimental mine for making the tests.

On November 30, 1917, the director wrote to Maj. Gen. Black introducing G. S. Rice, chief of the mining division, "whom I have intrusted with an investigation, suggested by you, into means of detecting sounds through the ground." In the letter the director called attention to Mr. Rice's experience in the detection of shock waves in air at the experimental mine of the bureau, 12 miles from Pittsburgh, where he had the assistance of W. L. Egy, physicist, and other men of scientific training. The director authorized Mr. Rice to obtain the services of such other engineers and scientists as might be available.

At that time investigations were being carried on in conjunction with the Bureau of Standards, and the original French geophones and other listening devices and instruments were under test. A map of the experimental mine was submitted to Lieut. E. B. Stevenson, afterwards captain, with the thought that this mine might be particularly useful in studying sound waves through earth and rock. At a conference between Gen. Black and Mr. Rice, regarding the general features of sound waves, Gen. Abbott was called in, who described sound measurements made at the time of the Hellgate blast in 1877. Mr. Rice also conferred with Gen. Winslow, who had charge of the division of work in which sound detection and ranging had been placed.

Early in December Lieut. Stevenson conferred with Mr. Rice in regard to what might be done through cooperation and the facilities available at the experimental mine. Lieut. Stevenson acknowledged the advantage of standardizing in point of sound production all the different kinds of noises from machines and other sources, made and transmitted through the strata in mining.

On December 15, Gen. Black asked that the services of G. S. Rice and W. L. Egy be placed at his disposal. In reply, Director Manning said that Messrs. Rice and Egy could not be spared from other important duties, but he would be glad to have them contribute what work they could, especially in connection with the use of the experimental mine for testing.

The project of undertaking the investigations at the experimental mine was taken up definitely with Mr. Egy on December 28. On January 4, 1918, Lieut. Stevenson inquired as to the character of underground sounds, the kind of detection so far employed, and the laws of sound transmission.

On January 11 and 17, 1918, Mr. Rice, in conference with Dr. W. J. Humphries, of the United States Weather Bureau, discussed the subject of sound or shock waves through ground. On the latter date the Bureau of Standards furnished plans of geophones and ear-pieces that had been developed at the Bureau of Standards by Lieut. Stevenson.



Later in the month Mr. Egy visited Prof. D. C. Miller, at Cleveland, Ohio, different physicists at Urbana, Ill., and Prof. Foley, of the University of Indiana, to discuss various questions of the physics of sound production. A report on the information gathered was submitted to Maj. Young, who had been placed in charge, for the Army, of all investigations relating to sound detection.

About January 20 a conference was held in Washington, at which Maj. Young, Capt. Wood, Mr. Egy, and Mr. Rice were present. As a result of this conference it was agreed that the bureau should take up (1) the standardization of sound waves by character and by the blows or forces employed under ground; and (2) should study the mechanical development of recording instruments for sound waves transmitted through earth or rock.

Under the first of these investigations, the problems proposed were determining the distance at which the blow of a pick, boring with a hand auger, cutting chips with a chisel by pressure, and talking, could be heard, one of the purposes of the tests being to procure information to guide in selecting the best types of boring and tunneling machines for military work. The investigations involved the detection of sound waves passing through air, unconsolidated material (soil and clay), and rock.

The work undertaken included reviewing the literature of shock and sound waves and method of detecting them; constructing geophones of the French type; training the personnel at the experimental mine in their use; placing listening stations in the experimental mine; and determining the distances at which different sounds could be heard through coal, shale, clay, and earth.

Work at the experimental mine began on January 22, 1918, under Mr. Egy. The first tests were with geophones to determine the distances at which different sounds could be heard in different directions through coal. Subsequent tests in February, March, and April showed that sounds were transmitted more readily through coal than through shale, and more readily through shale than through clay. Other tests determined how far standard sounds could be detected through the top soil, shale, and sandstone overlying the coal. Two types of French microphones were tested at the experimental mine in June, the tests including the distance at which the explosion of small charges of dynamite could be detected.

In September Alan Leighton, assistant physicist, went to Camp Humphreys, Md., and cooperated with officers of the Engineers Training School in tests with geophones and French microphones to determine the distances at which sounds could be heard through clay.

Eight reports were made on the various tests, and copies of the reports were sent to the office of the Chief of Engineers of the Army.

Mathematical analysis of the data obtained in the tests showed that the relationship between the energy of a blow or of an explosion of a given charge of dynamite can be expressed by an empirical formula that had been developed years before by Brig. Gen. H. L. Abbott.

Subsequently tests at the experimental mine to determine the applicability of geophones for use in detecting sounds made by men entombed by mine disasters were planned.

A seismograph devised by Prof. H. V. Carpenter, of the University of Washington, for detecting the shock of explosives was tested at the experimental mine.

### TRAINING IN FIRST-AID AND RESCUE WORK.

Perhaps the most important work done by mine safety stations and rescue cars of the Bureau of Mines was the training of soldiers in the use of oxygen breathing apparatus and in first-aid and rescue methods. Rescue car No. 8, with its crew, spent several weeks at Camp Meade, Md., training men for mining and sapping regiments in the use and care of breathing apparatus and in first aid, 184 being trained in mine rescue and 158 in first aid. At Edgewood Arsenal, where poison gases were made on a huge scale, the crew of rescue car 6 trained 66 men in the use of oxygen breathing apparatus and 65 in methods of resuscitation from gas. At Houghton, Mich., 809 soldiers of the Student Army Training Corps, Michigan College of Mines, were trained in the use of apparatus and 136 in first aid. Incidentally, training was given some of the Army officers detailed to the Pittsburgh station. The total number of officers and soldiers trained was 1,055. These men formed a nucleus from which instructors could be selected for training other groups.

Tests were made for the War Department of 200 sets of Gibbs oxygen breathing apparatus, at Orange, N. Y., also comparative tests of the Draeger (Atmos) and Fleuss half-hour apparatus were made at the Pittsburgh station for the War Department. These tests were under the supervision of D. J. Parker, mine safety engineer.

The mine-safety section at the Pittsburgh station assisted in testing soda-lime regenerators, gas masks, and gas detectors for the war-gas investigations. At Camp Dix assistance was rendered in some tests of gases from the detonation of high explosives.

In addition, thousands of miners throughout the country were trained in mine rescue and first-aid methods. Probably one-half of them were ultimately called to the colors. During the war period 10,665 men were trained in first aid and 4,075 in mine rescue methods. It is estimated that 6,509 of these men subsequently entered the Army or the Navy.

The crews of the cars and stations assisted at various mine disasters. By their experience in mine recovery work they were fre-



quently able to give aid or advice in exploring workings, extinguishing fires, or restoring ventilation that resulted in saving life and in hastening the resumption of production.

### **CENSUS OF MINING ENGINEERS, METALLURGISTS, AND CHEMISTS.**

As a measure toward national preparedness for war, the Bureau of Mines, at the request of the Council of National Defense, under date of February 24, 1917, undertook a census of mining engineers and chemists. The need for such a census was obvious. In the conduct of war to-day chemists and engineers play a far greater part than ever before. The products of the mines, furnaces, factories, and chemical plants are consumed so rapidly that the highest possible efficiency is required to keep pace with the enormous demand. In the organization of a great army many classes of specialists are needed. Men with a knowledge of sanitation were essential at the various training camps; men with an intimate knowledge of pyrotechnics could find a place in the manufacture and use of signal devices; chemists and engineers were needed at munitions plants. Coal and iron are absolute necessities for the manufacture of arms and munitions. Many naval vessels were dependent on petroleum as a fuel, and aircraft and motor trucks were useless without gasoline, or spirits obtained with greater difficulty.

Moreover, it was believed that mining engineers, under military control, could be of great assistance in directing sapping operations; in digging trenches, dugouts, and tunnels behind the lines; and in reinforcing, ventilating, and draining such excavations; in rehabilitating wrecked coal and iron mines taken from the enemy, and in increasing the output of minerals for military uses in other districts. It was on the theory of being able to place the right man in the right place at the right time that the census was conducted.

Work on this census began at once, mailing lists and questionnaires being compiled in cooperation with the American Institute of Mining Engineers and the American Chemical Society. A circular letter under date of April 6 was addressed to approximately 5,000 members of the American Institute of Mining Engineers and 9,000 members of the American Chemical Society. This letter requested that each recipient fill out and return a card accompanying the letter and make himself a committee of one to see that every chemist and engineer of his acquaintance likewise filled out a card.

As a result, the Bureau of Mines received replies from 7,500 men engaged in mining and from 15,000 men engaged in the various chemical industries. These 22,500 names were classified according to the character of the work in which each writer claimed proficiency. If any industrial plant engaged on Government contracts desired the

services of special men, the bureau, on request, endeavored to furnish such names.

In classifying the engineers and chemists no attention was paid to any occupation in which the individual had less than a year's experience, except where it was known that there were only a few experts in a certain branch. As many men had an experience of more than one year under several items, for some of these as many as five or six cards were made out. The total number of index cards for chemists was approximately 28,000 or an average of two for each person, and that for mining engineers was 30,000, or four for each engineer. The list of chemists and engineers having had experience abroad included only the names of those who had spent more than one year in a foreign land.

The census returns were followed by postal inquiries when the selective draft had been completed and the men knew their military status. This questionnaire asked each man in the Government service to give his new address, the name of the branch with which he was connected, and his official title. Then, if the War Department called for the names of men in certain lines of mining or chemistry, the bureau could select from the postal-card returns the names of men already in the military service who could be transferred where their work would be of greatest benefit.

On account of the importance of petroleum and its products, the Bureau of Mines prepared a classified list of men engaged in the industry. A circular letter was addressed to the principal operating companies requesting the names of their managers, drillers, pump men, transportation engineers, chemists, and refiners. The companies promptly furnished the required lists, and a registration card was sent each man named to fill out and return to the bureau. As a result a classified list of men in the petroleum industry containing 2,000 names was obtained.

Although the bureau's schedule was sent primarily to mining engineers and chemists, the questions relating to metallurgy were identical and were so arranged that anyone with experience in metallurgy could find the proper place to indicate the line along which he had worked. The number of metallurgists, by principal groups, were classified as from the returns of the mining engineers and chemists.

In order to furnish certain information—the names of men available for research work—to the chemistry committee of the National Research Council, a special letter and questionnaire were added to the regular chemist's form. When these forms were received at the office of the bureau they were detached and forwarded to Dr. Marston Taylor Bogert, chairman of the committee.

The taking of this census and the compilation of the information obtained by the questionnaires were in charge of A. H. Fay, engineer.



## INVESTIGATIONS OF ALLOY STEELS.

### COOPERATIVE WORK WITH THE ORDNANCE DEPARTMENT (WATERTOWN ARSENAL).

During February, 1917, the question of the value of uranium in steel for the liners of cannon became more pressing. According to rumors from abroad the Germans were using uranium steel in some of their special guns. After some preliminary discussion a conference was called at the Watertown Arsenal March 24, 1917, between Dr. H. W. Gillett, alloy chemist of the bureau, and officials appointed by the arsenal. On March 27 the Director of the Bureau of Mines received from the commanding officer of the arsenal a letter stating the determination of the influence of uranium on gun erosion was a matter that warranted thorough investigation. Accordingly work was begun at Ithaca by Dr. Gillett under the direction of C. L. Parsons, chief chemist of the bureau.

On April 12, 1917, the commanding officer of the Watertown Arsenal requested the Director of the Bureau of Mines to extend the investigation to molybdenum and tungsten steels. In the early fall of 1917, J. G. Thompson and Louis S. Deitz, jr., were inducted into the service, assigned to the Bureau of Mines, and later commissioned as second lieutenants to assist in this work. On July 17, 1918, Private E. O. Denzler was inducted into the Chemical Warfare Service and assigned to the alloy steel work at Ithaca.

As a result of the work done at Ithaca a large number of uranium and tungsten steels were prepared and submitted to the Watertown Arsenal. Because of delay in testing, samples were reshipped to the Bureau of Standards for investigation of their physical and chemical properties. Tests were not completed when the armistice was signed.

### COOPERATIVE WORK WITH THE NAVY DEPARTMENT AND THE BUREAU OF STANDARDS.

A question as to the light armor used in airplanes and tanks having arisen, it was deemed advisable to arrange a cooperative investigation with the Army, Navy, Bureau of Standards, and War Industries Board, and a conference was called by Commander Holmes of the Navy, to meet at the Bureau of Mines on August 9, 1918. After preliminary discussion the conferees adjourned until August 12 and met again on the 13th.

As a result a cooperative investigation of ferrozirconium and of zirconium steel as light armor was arranged with the Navy and the Bureau of Standards. This investigation was in charge of the Bureau of Mines, C. L. Parsons, chief chemist, acting as chairman of the joint board. The Ordnance Department of the Army at the same time began investigations of its own in cooperation with the

Ford Motor Co., of Detroit, Mich. The results achieved to February 1 did not show definitely that zirconium has any beneficial effect when added to steel, but it seems certain that the investigations will result in the manufacture of bullet-resisting armor much more effective than any heretofore used.

Ferrozirconium and some 60 steels alloyed with zirconium have been produced by the Bureau of Mines and were under test at the Bureau of Standards on February 1, 1919.

#### LIGHTING DEVICE FOR AVIATION FIELDS.

In December, 1917, Secretary Lane had his attention called to a portable lighting device for assisting aviators in night flying. This device consisted essentially of a motor-driven generating unit and suitable electric lights or projectors, both white and colored, mounted in such manner as to facilitate signaling to an aviator, illuminating the ground, and indicating in what direction a landing could be best be made, the whole device being mounted on a small motor vehicle. In January, 1918, the inventor, Otto H. Mohr, of Chicago, Ill., gave a demonstration of the device at the American University station of the Bureau of Mines, Dr. Durand, Chief of the Board of Aeronautics, and Director Manning being present. Dr. Durand strongly advised that the device be offered to the War and Navy Departments. On January 25 Secretary Lane called the device to the attention of Secretary Baker and to Secretary Daniels, suggesting they might wish to have it tried out under actual conditions. The Signal Corps of the Army finally took up the matter and the device received a preliminary test on April 6 at Langley Field, at the direction of Lieut. Col. R. A. Millikan, of the Signal Corps and the National Research Council. As a result of these tests a few changes were made in the device and a second trial made at Langley Field on April 25, with Lieut. J. T. Tait, representing the Science and Research Division of the Signal Corps, acting as observer. As a result of this second test the Science and Research Division recommended that a completely equipped unit be constructed on a light truck body and that further tests be made.

In making the tests and in building this unit, the Bureau of Mines, in which Mr. Mohr was a consulting electrical illuminating engineer, cooperated with the National Research Council and the Signal Corps, Lieut. Tait working under the direction of Mr. Mohr in completing the first unit, and the Signal Corps providing the truck and the generating equipment.

This unit was thoroughly tested at Ellington field, Tex., on August 9 to 20. As a result of these tests another unit was constructed under the direction of Lieut. Tait. In its final form, which differed



from the original chiefly in providing a more brilliant illumination over a larger area of ground, the device was approved by the Signal Corps and two units were built for each of the Government aviation fields.

#### COOPERATION WITH CAPITAL ISSUES COMMITTEE.

In accordance with its general policy of requesting those departments of the Government most thoroughly conversant with various subjects to cooperate with it, the Capital Issues Committee of the Treasury Department in May, 1918, asked the aid of the Bureau of Mines in establishing or checking statements of fact regarding mining companies applying for permission to issue new securities. In order to obtain the necessary information from the mining companies applying, the Capital Issues Committee requested the bureau to assist in drawing up a questionnaire or report form. In June the Bureau of Mines appointed a committee of its members to advise the Capital Issues Committee on mining and related applications. This committee consisted at different times of J. H. Mackenzie, H. H. Porter, H. S. Mudd, A. W. Stockett, and H. C. Morris. The committee carefully reviewed the evidence submitted through the Capital Issues Committee, and when necessary called for additional information, and sometimes had examinations and reports made by its own field or consulting staff.

Final decisions and matters of policy rested entirely with the Capital Issues Committee. The Bureau of Mines assisted in checking statements of fact and acted in an advisory capacity.

